TECHNICAL NOTES

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

No. 735

PRESSURE-DISTRIBUTION MEASUREMENTS ON A TAPERED WING WITH A PARTIAL-SPAN SPLIT FLAP IN CURVED FLIGHT

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SUMMARY

Pressure-distribution tests were made on the 32-foot whirling arm of the Daniel Guggenheim Airship Institute of a tapered wing to determine the rolling and the yawing moments due to an angular velocity in yaw. The model was tested at 0° and 5° pitch; 0°, 5°, and 10° yaw; and with split flaps covering 25, 50, 75, and 100 percent of the wing span and deflected 60°. The results are given in the form of load distributions and as calculated moment coefficients. The experimental values of rolling- and yawing-moment coefficients were in fairly close agreement with theory.

INTRODUCTION

An investigation of the pressure distribution over a model of a Clark Y tapered wing with full-span flaps made on the 32-foot whirling arm of the Airship Institute was reported in reference 1. Similar tests are reported in this paper with the same type of equipment but with the original full-span flaps converted into partial-span flaps covering 25, 50, and 75 percent of the wing span. The work was carried out with the financial assistance of the National Advisory Committee for Aeronautics.

APPARATUS AND TESTS

A complete description of the model, the flaps, the test set-up, and the test procedure is given in reference 1. Each half of the full-span flap described in the earlier tests was cut into four equal lengths and the resulting sections were added to or removed from the model to produce the desired flap length.

A few modifications of measuring equipment were nec-

essary for the partial-span flaps. Fourteen additional chordwise rows of pressure orifices were inserted along the span of the wing near the ends of the different flaps. The locations of the final 26 rows of orifices are shown in the sketch in figure 1.

The model with the 25-, the 50-, and the 75-percent-span flaps deflected 60° was tested at 0° and 5° pitch and at 0°, ±5°, and ±10° yaw. Positive yaw denotes a displacement of the model so that the leading edge faces the center of rotation. For the 5° pitch condition, tests were also made of the model without flaps and with full-span flaps at all the yaw angles. For all the tests, the ratio of the span to the turning radius was 0.133.

TEST RESULTS AND DISCUSSION

The pressure distribution over the upper and the lower surfaces of the airfoil is shown by plots of ratios of the static pressure p to the dynamic pressure q_o corresponding to the true flight velocity. Typical diagrams are given in figure 2 for different flap lengths and test conditions. The length of the flap is seen to affect the pressure distribution over the entire span. The maximum value of p/q_o at any chord section increased as the flap was lengthened.

The pressure diagrams for the various wing arrangements were then graphically integrated and, from the data thus obtained, nondimensional coefficients were computed for the wing as a whole. Table I shows the values of the rolling-moment coefficient C_l and the yawing-moment coefficient C_n obtained by integration. The local normal-force coefficient c_n and the local chord-force coefficient c_c are plotted in figures 3 and 4, respectively.

The coefficients are defined as follows:

$$C_l = \frac{L}{q_o\ b\ S} \qquad C_n = \frac{N}{q_o\ b\ S} \qquad c_n = \frac{n}{q_o\ c_{local}} \qquad c_c = \frac{c}{q_o\ c_{local}}$$

where

L is the rolling moment.

N, yawing moment.

n, normal force per unit span along longitudinal axis of wing.

c, longitudinal force per unit span.

b, wing span.

S, wing area.

c_{local}, chord of airfoil section.

The theoretical rolling-moment and yawing-moment coefficients were computed according to the method of reference 2. The theoretical rolling moment L is defined by

$$L = C_{l_r} \frac{rb}{2V} q S b$$

and the theoretical yawing moment N is defined by

$$N = C_{n_r} \frac{rb}{2V} q S b + q \int_{-b/2}^{b/2} c_{d_o} \frac{R + y}{R} y \, dy$$

where

C_{l_r} is the rolling-moment coefficient obtained from reference 2.

r, turning speed, radians per second.

V, flight velocity.

q, dynamic pressure.

C_{n_r}, yawing-moment coefficient obtained from reference 2.

c_{d_o}, local profile-drag coefficient.

R, turning radius at center of wing.

y, distance along span.

For the Clark Y wing without flap, the angle of attack for zero lift was assumed to be -4.8°. For the con-

dition of 0° pitch, this value gives $\alpha = 4.8°$ and, for the condition of 5° pitch, 9.8°. The 25-percent-chord flap deflected 60° was assumed to be equivalent to an increase of the effective angle of attack equal to $\Delta\alpha = 14°$. This effect of the flap was assumed on the basis of figure 4 of reference 3.

The profile-drag coefficient was assumed to be 0.01 for the wing without flap. For the wing with flap, the value of C_D was taken from figure 4 of reference 3 as 0.28 at $\alpha = 0°$. With $c_{d_i} = 0.08$ at $C_L = 1.3$ for zero angle of attack of the reference wing with an aspect ratio of 6.1, a value of $c_{d_o} = 0.20$ is obtained for the Clark Y wing with a 25-percent-chord split flap deflected 60°.

Figure 5 gives a comparison between the experimental and the theoretical rolling-moment and yawing-moment coefficients for the 0° yaw position and the positions of 0° and 5° pitch.

CONCLUSIONS

1. The experimental rolling- and yawing-moment coefficients for a wing without flaps are in close agreement with the theoretical values.

2. For a wing with a full-span or a partial-span flap, the experimental rolling-moment coefficients are 10 to 15 percent smaller than the theoretical values.

3. The rolling-moment coefficients were little affected by angle of yaw within the range of ±10° with a tendency to decrease as the model was yawed in the positive direction. The yawing-moment coefficients were little affected by the angle of yaw for flap lengths up to 50 percent of the span but showed considerable change for the full-span flap with a tendency to increase as the model was yawed in the positive direction.

Daniel Guggenheim Airship Institute,

Akron, Ohio, June 1939.

REFERENCES

1. Troller, Th., and Rokus, F.: Pressure-Distribution Measurements on a Tapered Wing with a Full-Span Split Flap in Curved Flight. T.N. No. 683, N.A.C.A., 1939.

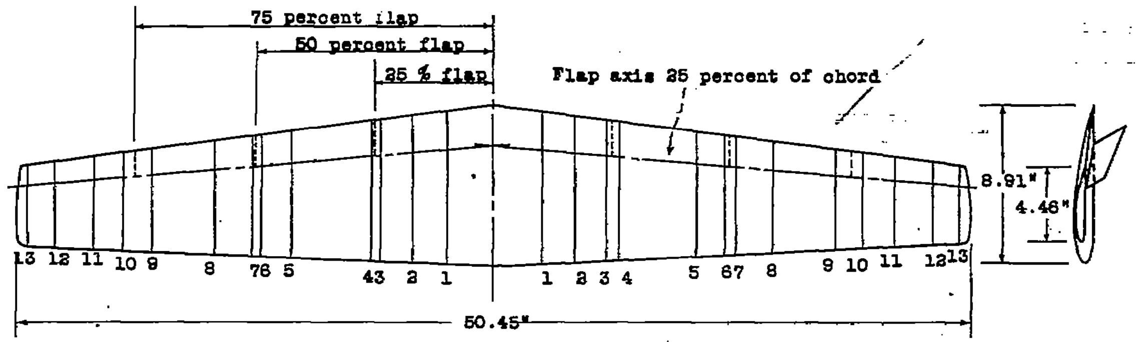
2. Pearson, Henry A., and Jones, Robert T.: Theoretical Stability and Control Characteristics of Wings with Various Amounts of Taper and Twist. T.R. No. 635, N.A.C.A., 1938.

3. Wenzinger, Carl J.: The Effects of Full-Span and Partial-Span Split Flaps on the Aerodynamic Characteristics of a Tapered Wing. T.N. No. 505, N.A.C.A., 1934.

TABLE I. Moment Coefficients Obtained by Integration

Angle of yaw (deg.)	C_l					C_n				
	No flap	25-percent flap	50-percent flap	75-percent flap	100-percent flap	No flap	25-percent flap	50-percent flap	75-percent flap	100 percent flap
	0° pitch									
10	--	0.0055	0.0075	0.0128	--	--	0.00093	0.00179	0.00373	--
5	[a]0.0073	.0072	.0079	.0128	[a]0.0225	[a]0.00033	.00087	.00161	.00360	[a]0.00832
0	[a].0076	.0090	.0087	.0138	[a].0229	[a].00033	.00070	.00146	.00267	[a].00514
-5	--	.0092	.0102	.0150	--	--	.00062	.00102	.00192	--
-10	--	.0082	.0098	.0150	--	These coefficients considered unreliable				
	5° pitch									
10	0.0127	0.0127	0.0144	0.0189	0.0284	0.00100	0.00133	0.00263	0.00576	0.01075
5	[a].0131	.0120	.0150	.0196	[a].0279	[a].00073	.00120	.00193	.00480	.01029
0	[a].0136	.0124	.0153	.0203	[a].0282	[a].00073	.00114	.00200	.00435	.00693
-5	.0130	.0143	.0177	.0233	.0310	.00073	.00105	.00200	.00395	.00620
-10	.0120	.0137	.0187	.0267	.0317	These coefficients considered unreliable				

[a]Data from reference 1.



Chord	Distance from center of span, in.	Chord	Distance from center of span, in.	Chord	Distance from center of span, in.
1	2.63	5	10.88	10	19.58
2	4.33	6	12.33	11	21.38
3	6.03	7	12.83	12	23.32
4	6.63	8	14.88	13	24.62
		9	18.13		

Figure 1.- Sketch of wing showing location of pressure-orifice chords.

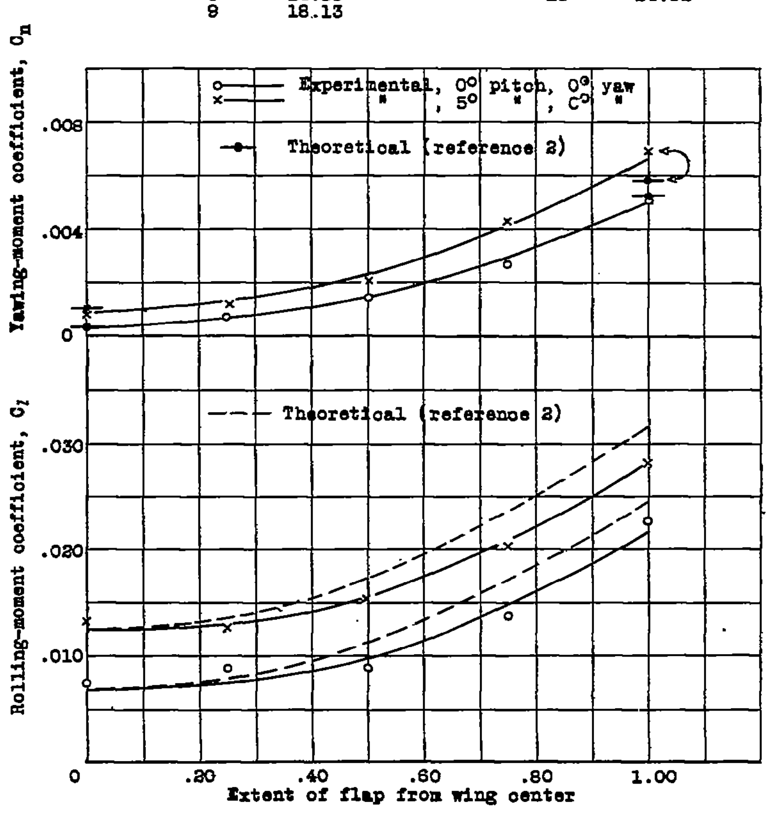
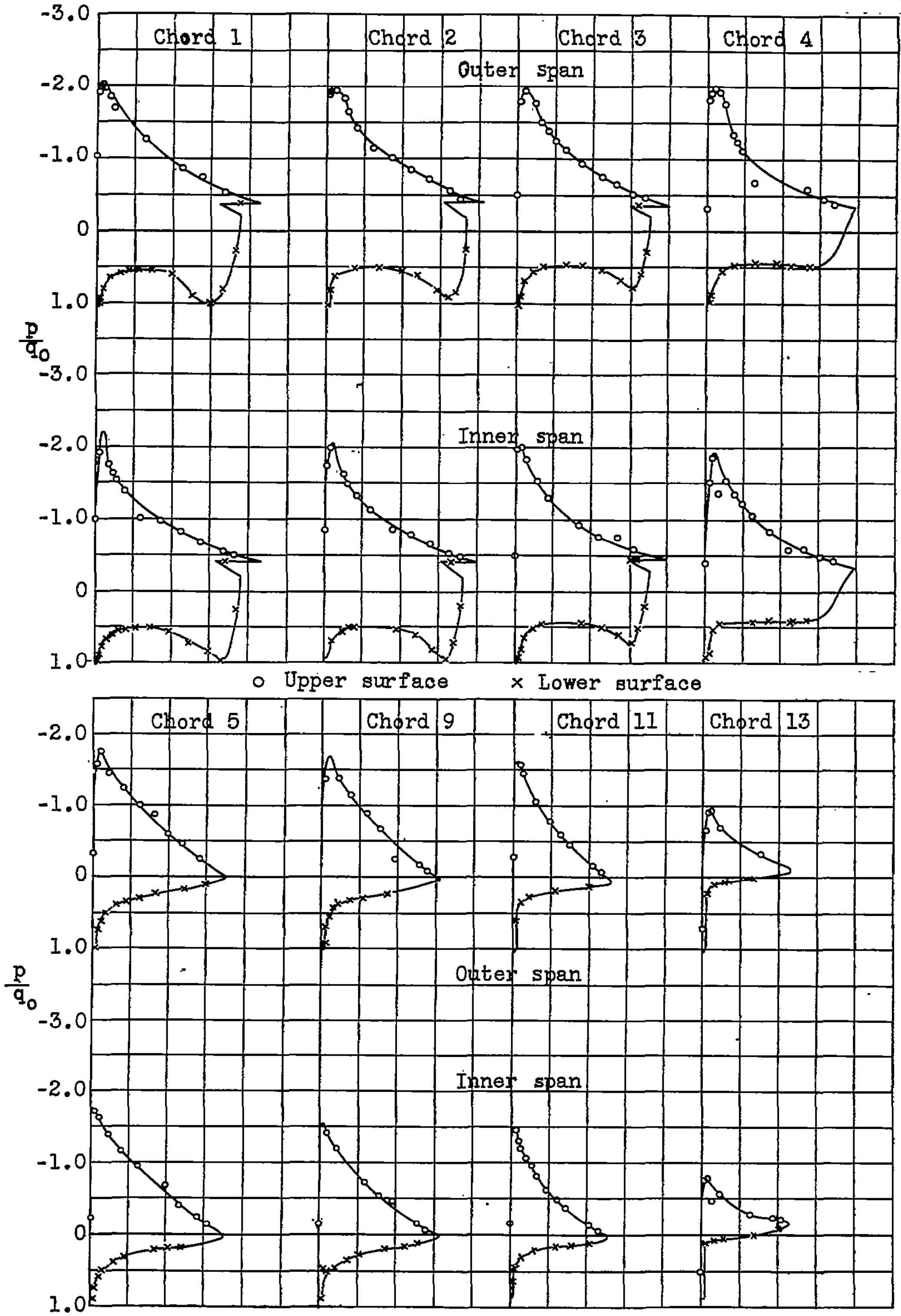
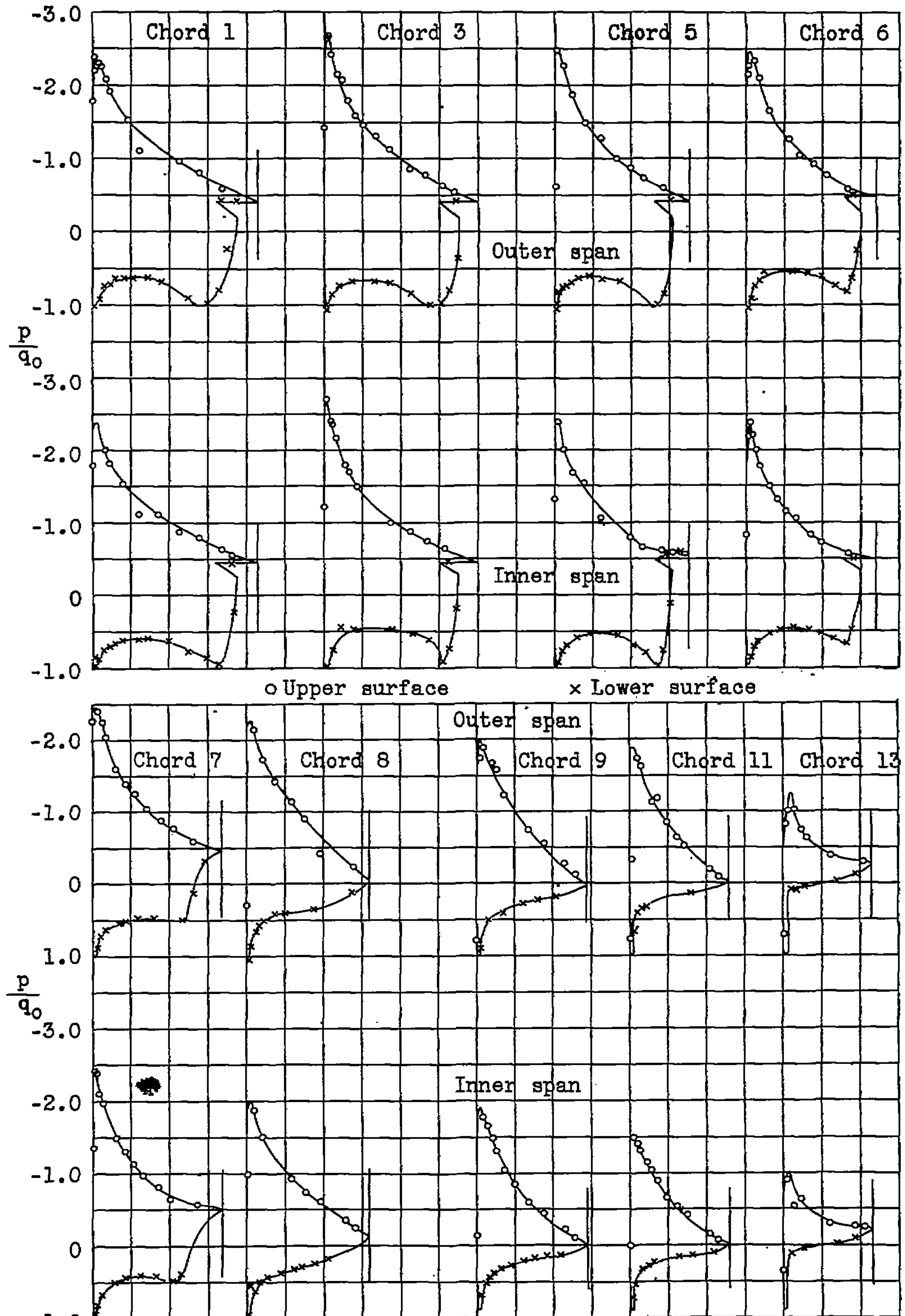


Figure 5.- Comparison of theoretical and experimental rolling-moment and yawing-moment coefficients.



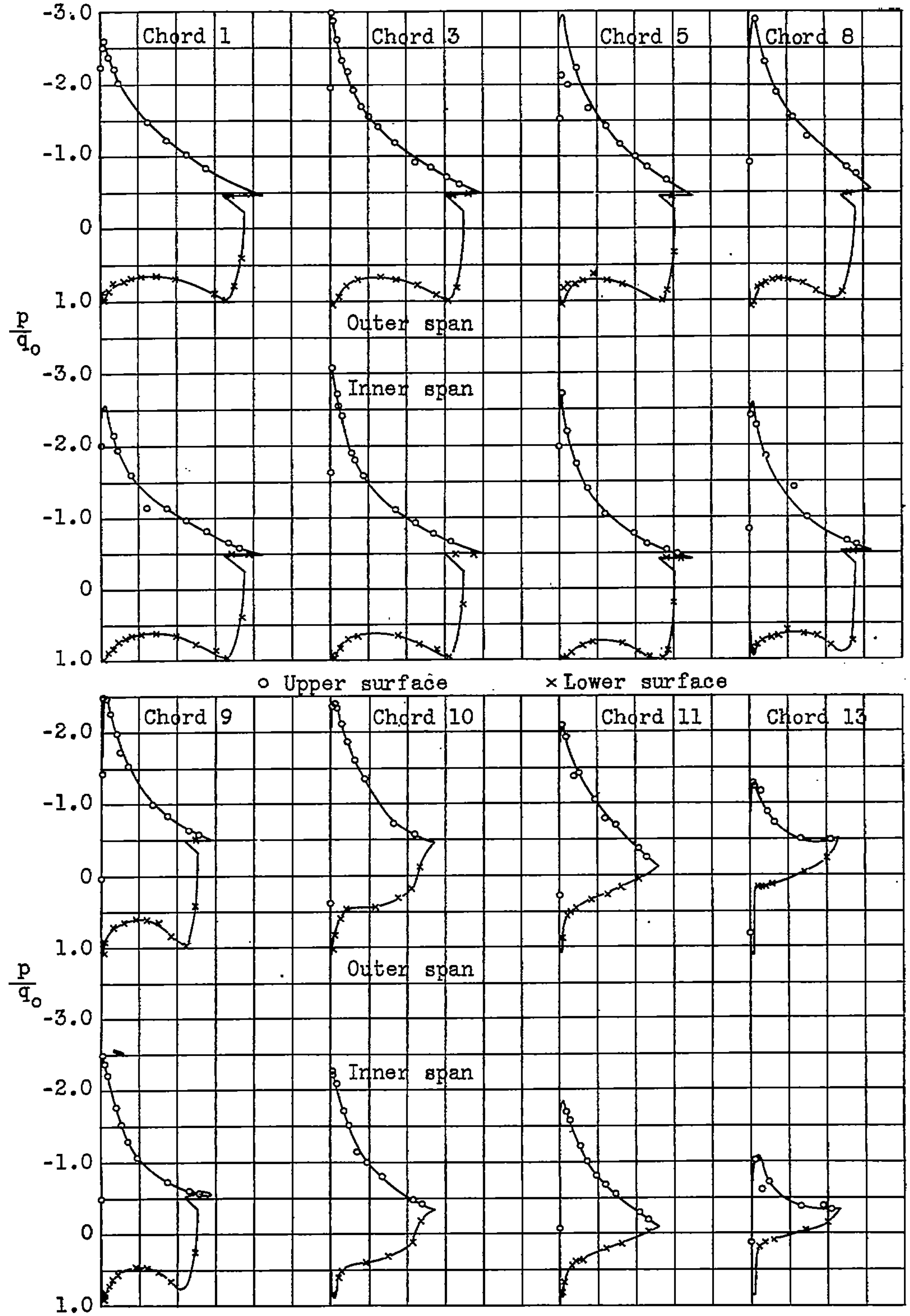
(a) The 25-percent-span flap.

Figures 2a to c.- Pressure-distribution plots for 5° pitch, 0° yaw, flaps deflected 60°.



(b) The 50-percent-span flap.

Figure 2.- Continued.



(c) The 75-percent-span flap

Figure 2.- Concluded.

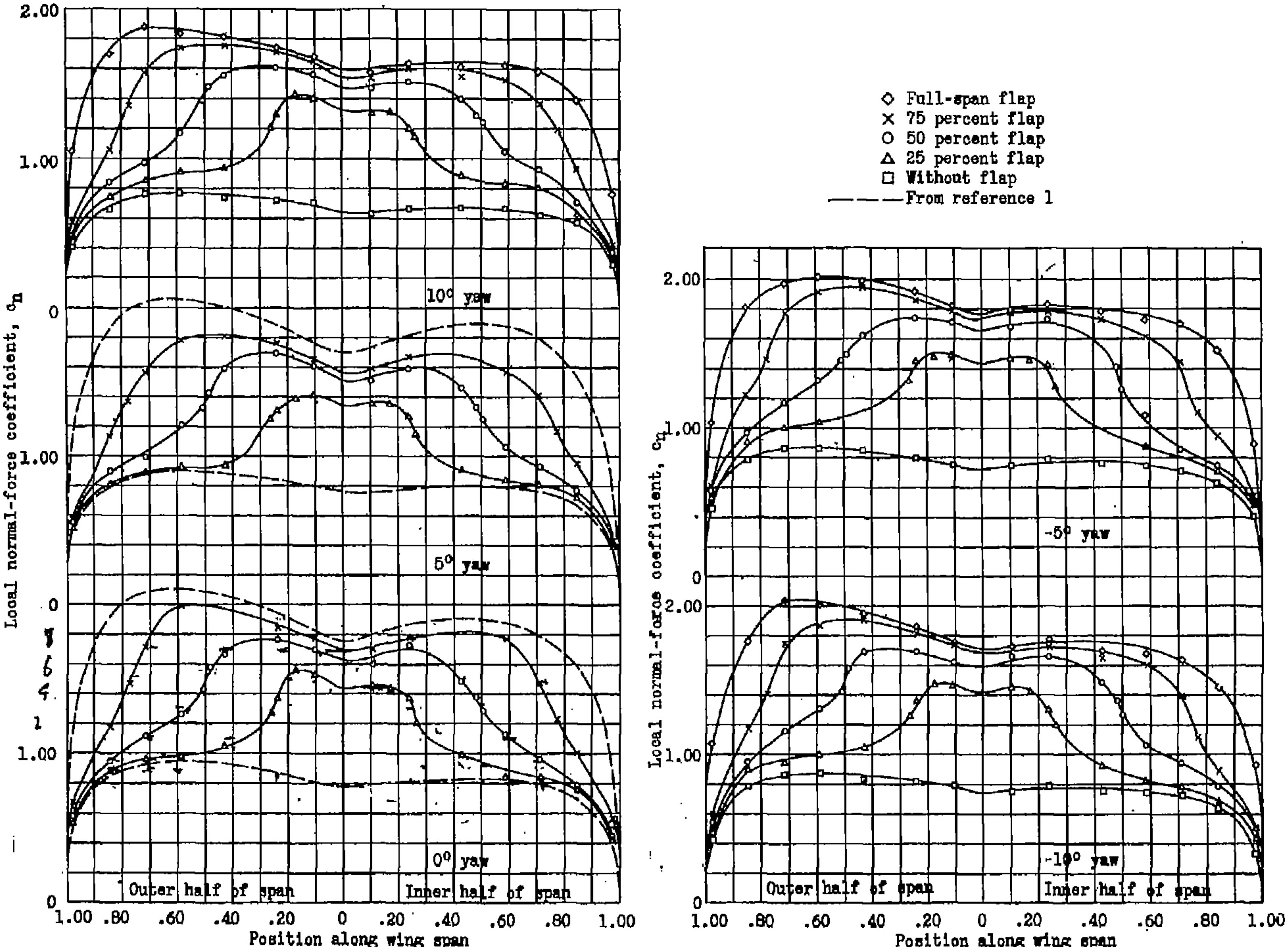


Figure 3.- Distribution of normal-force coefficients along span of wing; pitch, 5°.

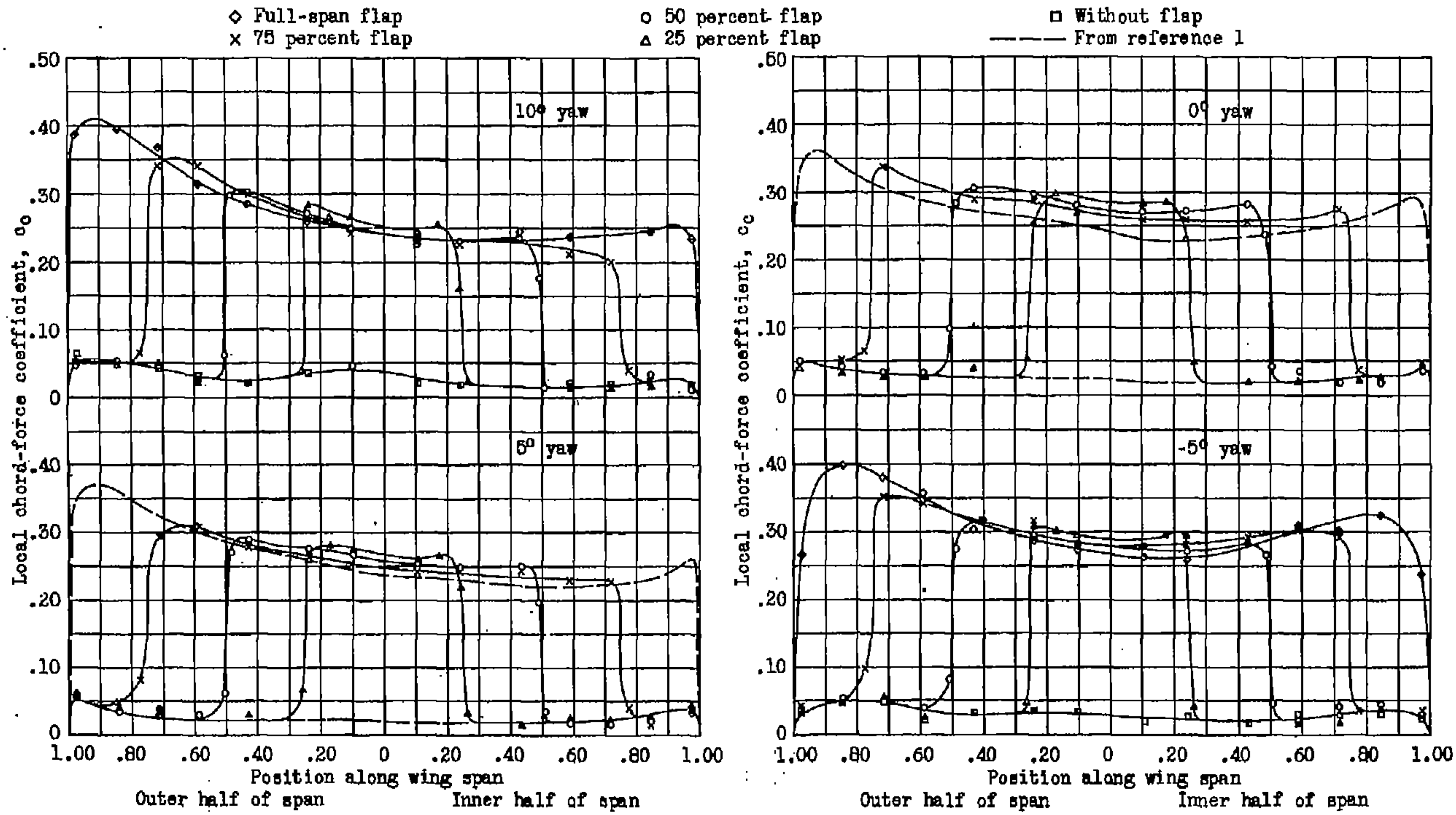


Figure 4.- Distribution of chord-force coefficients along span of wing; pitch, 5°.